EVIDENCE BOOK

Infection Control

At NSK we believe that we have a responsibility to help protect clinicians and patients against infections. That is why we have been actively looking for solutions to improve cross- infection control for over 30 years. In this time we have accumulated knowledge and experience which makes us the leading brand for infection control in rotary dental instruments in the world.
NSK's proprietary 'Clean Head System' prevents ingress of foreign matter in the dental handpiece and our 'Anti Retraction Valve' helps to prevent cross-contamination in the water line, a feature which can be found in many of our products. The effectiveness of this Dual Defence system has been proven by five well-known universities including Washington/USA, Umeå/Sweden and Singapore.
This document is introducing and sharing our achievements as pioneering brand in the field of cross-infection control in dental handpieces.

DualDefence™

Proprietary Infection Control by NSK

NSK instruments are designed with Dual infection protection.
The Clean Head System prevents suck back into the head and the exhaust line and the Anti-Retraction systems prevent contamination of the water supply.

History

1987

NSK started its own research and development of infection control technology in 1986 and invented an Anti-Retraction Valve (ARV) to prevent suck back in the water line and built the World's first high speed handpieces with ARV in 1987. This technology was patented in 1990.

1990

NSK invented the Clean Head System (CHS) to prevent suck back in the drive air line of high speed handpieces. Another World's first with patented status following in 1994.

1993

The CHS received the SITAD Applied Technology Award in France as the World's first infection prevention system which greatly contributed to dentistry.

The university of Umeo, Sweden, proved that CHS reduced cross-contamination greatly.
More studies about the effectiveness of anti suck-back system of the CHS and ARV had been done and had proven by four other well-known universities between 1994 and 2007.

1996

All NSK high speed handpieces and low speed handpieces were fitted with CHS and all couplings with ARV.

2020

In-house testing confirmed the advantage of CHS once again.
"n-cid" a chemical solution of " iCare+ ", automatic system for cleaning, disinfection and lubrication for instruments, was certified for the positive effect on Covid-19 by a laboratory in Germany.

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Bacterial contamination of high-speed air-driven handpieces

University of Umea, Sweden, 1993

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Department of Oral Microbiology, University of Umeå,
S-901 85 Umeå, Sweden
A report submitted to Nakanishi Dental MFG. Co., LTD. (NSK), 1993

Introduction

We were asked by Mr. Göran Kjellberg, TS Dental Sales, Vännäs, Sweden, to test for possible bacterial contaminations of the Phatelus-II handpiece.

Material and Methods

Handpieces.

Phatelus-II, Nakanishi Dental MFG. Co., LTD., Japan, and Super-Torque 630B, Kavo AG, Germany, were tested.

Bacteriological media.

To preserve the viability of bacteria emitted from the handpieces we used a buffer solution, modified from Möller (1966), which contained per liter: 4.3 g sodium chloride, 0.42 g potassium chloride, 1.0 g disodium hydrogen phosphate, 1.0 g potassium dihydrogen phosphate, 10.0 g sodium glycerophosphate, 0.24 g calcium chloride and 0.1 g magnesium chloride. Mitis salivarius agar (Difco Laboratories, Detroit, USA) was prepared according to the instructions given by the manufacturer. Blood agar was prepared according to Holdeman et al. (1977). The broth to culture spores of Bacillus stearothermophilus contained per liter: Tryptone (Difco) 5 g, yeast extract (Difco) 3 g, disodium hydrogen phosphate 1.6 g, 24 mg bromthymol blue (in ethanol), and glucose 5 g, pH 7.8. The broth was autoclaved at 121°C for 20 min. The glucose of the broth was autoclaved separately.

Experimental procedures.

Experiment 1.

At the start of the experiment the coupler of the handpiece and the connecting end of the hose were immersed into 45% (v/v) isopropyl alcohol. The hands of the operator were covered with rubber gloves. The handpiece was autoclaved for 20 min at 121°C and then treated with oil spray. To test for contaminating bacteria the coupler and the connecting end of the hose were each immersed into 10 ml buffer solution in a 100-ml flask (Step 1 and 2, Fig. 1). The equipment was then assembled and the head of the handpiece was submerged into 10 ml buffer solution in 100-ml flask, and the air turbin was started and stopped 10 times (Step 3, Fig. 1). After this test for contaminating bacteria the head of the handpiece was submerged into 10 ml saliva stimulated by chewing on a piece of paraffin (Step 4, Fig. 1). After the air turbin had been started and stopped 10 times, the handpiece was wiped with a dry wad. The handpiece was introduced into a 100-ml flask with 10 ml buffer solution, and the air turbin was run for 30s over the surface of the buffer (Step 5, Fig. 1). Thereafter the handpiece was wiped with 45% isopropyl alcohol (Step 6, Fig. 1). The head of the handpiece was submerged into 10 ml of buffer solution of another 100-ml flask and the air turbin was started and stopped 10 times (Step 7, Fig. 1). The handpiece was again wiped with 45% isopropyl alcohol (step 8, Fig. 1). The coupler of the handpiece, and the connecting end of the hose were each immersed into 10 ml buffer solution (Step 9 and 10, Fig. 1). Saliva and the buffer solutions from step 1 to 10 (Fig. 1) were diluted in buffer solution and 0.1- ml aliquots were spread over the surface of blood agar and mitis salivarius agar plates (Fig. 1). The

plates were then incubated for 2 d at 37°C in air supplemented with 5% (v/v) carbon dioxide. On plates from appropriate dilutions the total number of colonies were counted. On mitis salivarius agar the number of colonies of Streptococcus salivarius were also counted.

Experiment 2.

The handpiece was treated with oil spray. The handpiece, the coupler, and a hose with silicon tubing were assembled, and (except for the head of the handpiece) covered with autoclavable tubing. This package was placed in an autoclave. To replace the air of the autoclave chamber with steam, the autoclave was evacuated three times to -0.8 bar. The pressure of the steam was thereafter increased and the temperature was kept at 135°C for 7 min. To dry the material after this treatment the autoclave chamber was evacuated and the pressure was kept at -0.8 bar for 5 min. The autoclaved package of handpiece, coupler, and hose was then covered with another layer of autoclavable tubing (except for the head of the handpiece) as a further protection against contamination of the equipment from outside. The hose was connected to compressed air, and the head of the handpiece was submerged into 10 ml of a suspension of Bacillus stearothermophilus spores (1 x 10^6/ ml) in a 100-ml flask. This suspension of heat-resistant spores was kindly supplied by Dr. Ingemar Juhlin, AB Spordisk, Bellevueväg 64, S-216 19 Malmö, Sweden. The air turbin was started and stopped 10 times. The package was disconnected from the compressed air. The covering outer tubing was removed. Under aseptic precautions the coupler and the connecting end of the hose were each immersed into 15 ml broth. This broth was incubated for 7 d at 56°C. The handpiece was then autoclaved again and after the covering mantel had been disconnected, it was put into 250 ml broth and incubated for 7 d at 56°C.

Results

Experiment 1.

There were few contaminating bacteria on the equipment before the head of the handpiece was exposed lo saliva (Step 1, 2, and 3, Fig. 1; Table 1). No salivary streplococci were detected on the coupler. On the connecting end of the hose one colony of Streptococcus salivarius was detected on one out of 18 occasions. The handpicce did not emit any salivary streptococci, when the head was submerged into buffer solution and the air turbin was started and stopped 10 times (Step 3, Fig 1; Fig. 2 and Table 1).

In saliva there were $6.3 \pm 3.7 \times 10^8$ facultatively anaerobic bacteria growing on blood agar, and $9.3 \pm 0.6 \times 10^7$ streptococci growing on Milis salivarius agar. Of the streptococci Streptococcus salivarius made up 55%.

After the handpiece had been exposed lo saliva (step 4, Fig. 1) and the air turbin of the handpiece was run over the surface of the buffer (step 5, Fig. 1; Fig. 2 and Table 1),

10^6 to 10^7 bacteria left the Kavo handpiece, and
10^5 to 10^6 bacteria left the NSK handpiece.

After the handpiece was wiped with isopropyl alcohol, the head submerged into buffer, and the air turbin of the handpiece was started and stopped 10 times (step 7, Fig. 1; Fig 2 and Table 1),

10^5 to 10^6 bacteria left the Kavo handpiece, and
10^4 to 10^5 bacteria left the NSK handpiece.

In both step 5 and step 7 salivary streptococci left Kavo and NSK handpieces. After step 7 the handpiece was again wiped with isopropyl alcohol, and the equipment was dissembled. The coupler was immersed into 10 ml buffer. On the coupler of Kavo handpiece there were 10^4 to 10^6 bacteria (step 9, Fig. 1; Fig. 2 and Table 1). In one case there were no bacteria on the coupler. This was the last of three Kavo handpieces tested in a batch of saliva and the previous two handpieces had sucked up so much of saliva that the head of the third handpiece was not covered with saliva. Only one of the NSK couplers was contaminated to the same extent as the Kavo couplers by salivary streptococci. On one other NSK coupler a few salivary streptococci were detected. On the other NSK couplers no salivary streptococci were detected. On the hose connected to the Kavo handpiece similar number of bacteria was detected as on the coupler (step 10, Fig. 1; Fig. 2 and Table 1). On no NSK hose was any salivary streptococci detected (step 10, Fig. 1; Fig. 2 and Table 1).

These results clearly showed that the coupler and the hose of the Kavo handpiece were heavily contaminated by oral bacteria during operation. However, it was not clear whether the coupler and the connecting end of the hose of the NSK handpiece become contaminated by oral bacteria during operation or became contaminated from the outside.

Experiment 2.

In this experiment the handpiece, the coupler, and the hose were assembled, autoclaved, and handled in such a way that a contamination of the coupler and the connecting end of the hose from the outside was prevented, when the air turbin was started and stopped in a spore suspension. By using heat-resistant spores of Bacillus stearothermophilus and culture in broth at 56°C, a single living spore on the coupler or the connecting end of the hose could be detected. As long as no other bacteria are able to grow at 56°C, this test is very reliable.

After the three Kavo handpieces were exposed to the spore suspension, the coupler and the connecting end of the hose were heavily contaminated by spores. This confirmed the results of experiment 1.

After the three NSK handpieces were exposed to the spore suspension, no living spores were detected on the coupler, or on the connecting end of the hose. This experiment was repeated three times with the same result.

The Kavo and NSK handpieces were autoclaved after the exposure to the heat-resistant spores of Bacillus stearothermophilus. No living spores could then be detected on the handpieces.

Discussion

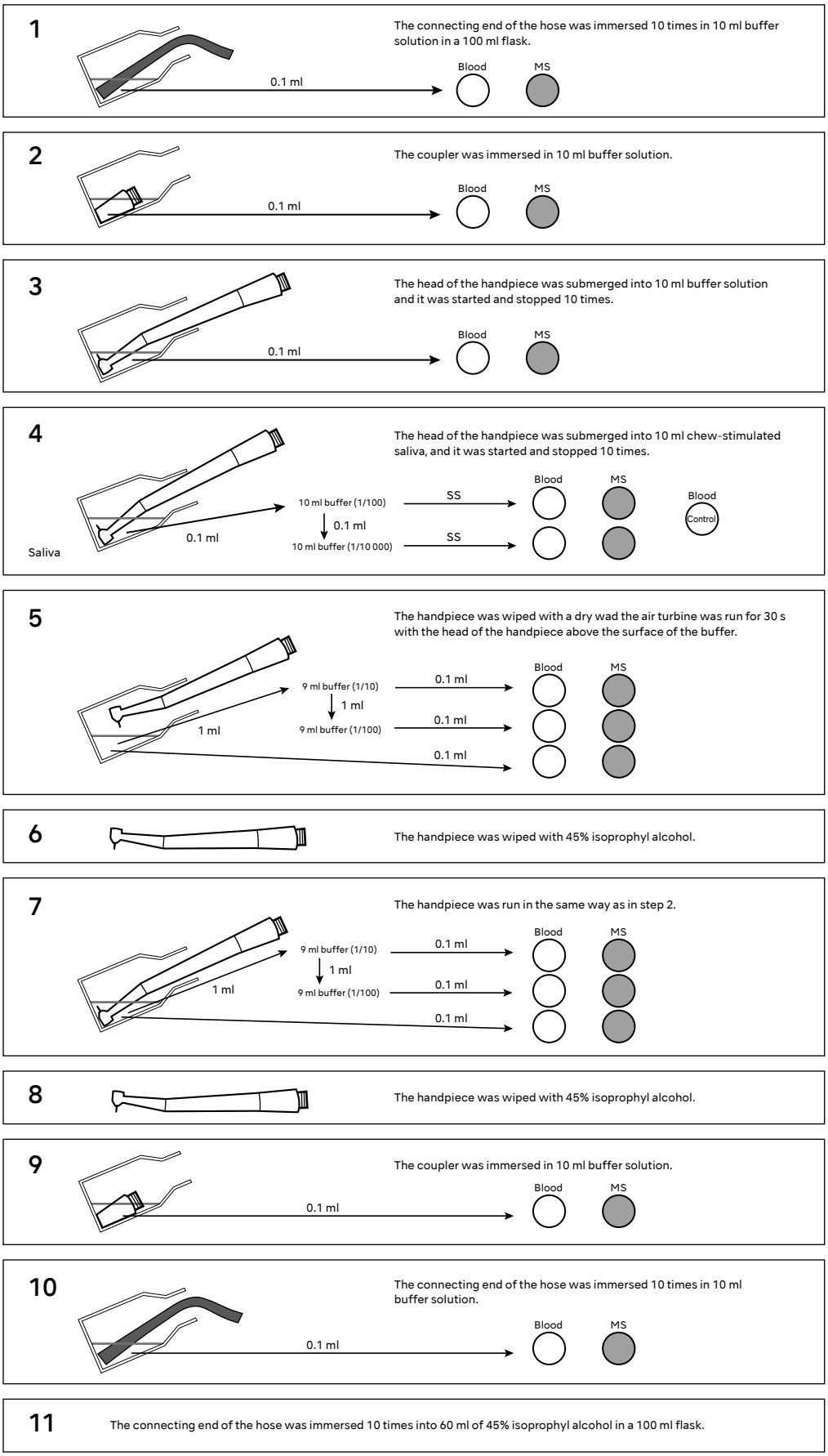
The Kavo and NSK handpieces became heavily contaminated by salivary bacteria during operation in saliva. After an alcohol desinfection of the outside they released, during running, significant numbers of bacteria. These results clearly showed that the handpieces have to be autoclaved after each patient in the dental practice to prevent cross-contamination between the patients.

With the Kavo equipment not only the handpiece, but also the coupler and the hose, became heavily contaminated during operation. This calls for sterilization by autoclaving also of the coupler and the hose after the treatment of each patient. The coupler and the hose of the NSK equipment were not contaminated in our experiment. If this is true also for the operation of the NSK handpiece in dental practice, a good hygienic standard can be maintained without autoclaving the coupler and the hose after treatment of each patient. The coupler and the hose of the NSK equipment should, however, be treated with disinfectant as other parts of the dental unit after the treatment of each patient.

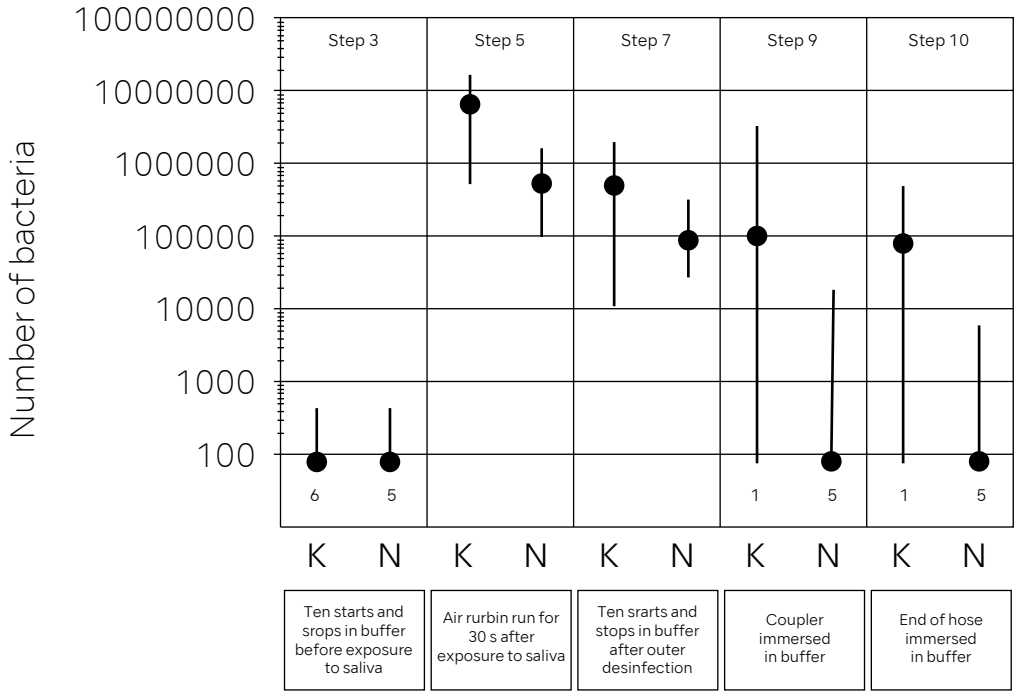
References

Holdeman LV, Cato EP, Moore WEC. Anaerobe laboratory manual. 4th ed., Virginia Polytechnic Institute and State Univerisity, Blacksburg, Virginia, USA, 1977.
Möller ÅJR Microbiological examination of root canals and periapical tissues of human teeth. Methodological studies. Scand Dent J 1966: 74: special article.

[Fig. 1.] The experimental procedure in testing the bacterial contamination of handpieces.



[Fig. 2.] The number of bacteria emitted from high-speed air-driven handpieces before and after exposure to saliva. Three Kavo Super-Torque 630B (K) and three NSK Phatelus-II (N) were tested three times. Median number and range of values are given. The number of tests in which <100 bacteria were detected is indicated in the figure. The bacteria were grown for 2 days on blood agar in an atmosphere of air with 5% carbon dioxide.



[Table 1.] The number of bacteria detected in various steps in testing Kavo (K) and NSK (N) handpieces according to fig. 1. The bacteria were cultured on blood agar for 2 d in an atmosphere of air with 5% carbon dioxide. <100 means that no bacteria were detected on the blood agar plates.

Step	1		2		3		5		7		9		10	
Experiment	K	N	K	N	K	N	K	N	K	N	K	N	K	N
1 : 1	<100	<100	100	100	<100	400	8000000	540000	460000	290000	64000	<100	600	5200
1 : 2	600	200	<100	<100	<100	100	8000000	320000	1100000	77000	34000	18000	40000	100
1 : 3	<100	300	<100	900	<100	<100	1000000	860000	10000	160000	<100	300	<100	<100
2 : 1	<100	<100	100	<100	400	<100	2000000	150000	400000	100000	160000	500	160000	<100
2 : 2	700	<100	100	200	<100	<100	5000000	1500000	1000000	50000	350000	3300	400000	<100
2 : 3	<100	<100	100	100	200	<100	15000000	500000	410000	80000	160000	<100	160000	200
3 : 1	<100	<100	<100	<100	<100	100	6000000	90000	240000	40000	140000	<100	70000	2200
3 : 2	200	<100	100	<100	300	<100	8000000	210000	1200000	20000	100000	<100	140000	300
3 : 3	4300	100	<100	<100	<100	<100	6000000	700000	620000	50000	70000	<100	34000	<100

A Newly Designed Turbine Handpiece System for Cross-infection Control

Niigata University and Tohoku University, Japan, 1994

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Niigata University School of Dentistry, Niigata, [1]Nakanishi Dental Mfg. Co., Ltd. and [2]Tohoku University School of Dentistry, Sendai, Japan

Manuscript for FDI table clinic presentation, 82nd FDI World Dental Congress, 1994

Introduction

In daily dental practice, the air turbine handpiece is continuously exposed to oral microbes. So, changing handpiece for each patient is generally recommended as the recent rule to avoid cross-infection. However, it is not enough to sterilize the handpiece only, because contamination may extend in the tubing beyond the handpiece by suck back, temporarily stored in there, and gushed back into the next patient's mouth. Therefore, a new handpiece system that completely block the contamination by itself should be expected.

We hence, tested the efficacy of a newly designed handpiece which prevents internal contamination, in a stand-alone fashion.

In conventional systems, internal contamination usually occurs when either of two events takes place (Fig. 1);- In the first, the water retraction valve creates a back-flow, which may aspirate patient materials back into the water-line immediately after the turbine has stopped. In the second, post shut-off inertial rotation of the turbine rotor, produces negative air-pressure within the turbine head, which, in turn, causes infiltration of patient materials.

Fig. 2 shows the re-designed unit, with its protective structures, which dramatically eliminate the risk of contamination. A silicone valve, called a "Duckbill", is inserted in the water line of the connector. An air-pressure reliever, called a "Labyrinth", is located at the entrance of the bur.

The Labyrinth, with its system of alternating narrow and wide air channels, act to relieve any vacuum pressure accumulating during inertial rotation. A disk is attached to the shaft and slits are just beside the disk. So, when the turbine is in operation, the air flow created by the disk ejects debris-laden water through the slits, thereby keeping the entrance of the Labyrinth clean. In brief, the Duckbill protects the water line, while the Labyrinth protects the head.

Materials and Methods

To assess the degree of protection, E.coli suspension was used to simdate infected patient materials, and the extent of contamination was estimated after intermittent driving.

The new handpiece with the Labyrinth (Fig . 3 left) and a conventional handpiece (fig. 3 right) were tested in this study.

Fig. 4 shows a disassembled new type handpiece. The head of the unit contains a rotor and a spring washer. Four ducts run in the body of the handpiece. The handpiece and drive-unit are connected by four tubes. This system of ducts and tubes simultaneously channel drive-air, exhaust, chip air and coolant water.

The new handpiece was tested, both with and without the Duckbill. A conventional handpiece served as the control. Prior to testing, handpieces and connectors were autoclaved. Water lines in the portable drive-unit and the tubes connecting it to the handpiece were disinfected with 70% ethanol, and then washed with sterile, distilled water.

In the first experiment (Fig. 5 left), the head of each handpiece was dipped in E.coli-saline suspension, after which the turbine was run for 10 seconds, and switched off. The head was kept in the suspension for 10 seconds. This cycle was repeated ten times per test.
In the second experiment (Fig. 5 right), the unit was run while the head was dipped in suspension, then removed from the solution before switching the turbine off. This cycle was also repeated ten times.
After completion of the 10 cycle tests, the handpiece was wiped with a sterile cloth and disassembled.
Bacteria were recovered from several areas (Fig. 6). The spring washer and the swab of the rotor blades were immersed in liquid culture medium. The ducts and tubes were washed with saline, and aliquots were seeded over agar plates. They were incubated at 37 degrees centigrade for 48 hours. Bacterial growth was estimated from the turbidity of the broth culture and colony-forming unit on agar plates. As to conventional handpieces, specimens were taken from the tubes only, because they were not designed to be disassembled. All experiments were performed in triplicate.

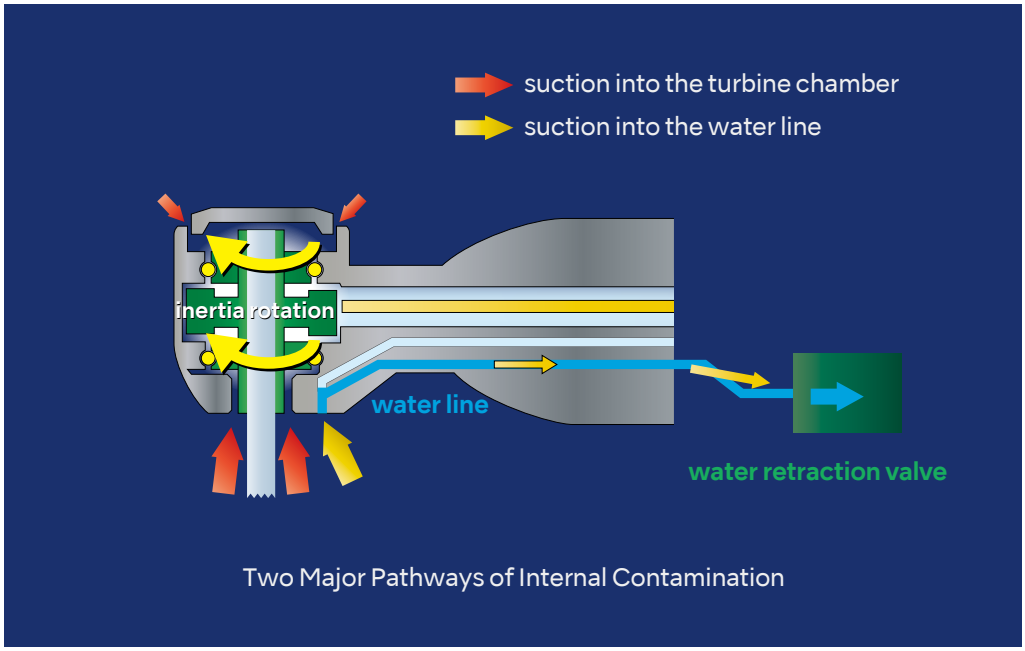
Results and Discussion

The results of the first experiment are shown in Table 1. When equipped with the Duckbill, E.coli contamination of the spring washer in the new unit occurred in only one case. Trace E.coli was recovered from only one drive air duct. By simply removing the Duckbill, detection of E.coli from the water line increased considerably. In this case, bacteria apparently reached the tube. On the conventional handpiece, far greater amount of bacteria reached the tubes. Especially, the water tube and the exhaust tube were highly contaminated. This would all seem to suggest that the head, the water and exhaust ducts of the conventional handpiece are highly contaminated.
In the second experiment (Table 2), bacterial contamination of the new handpiece was limited to the spring washer, regardless of whether the Duckbill was in place. Few bacteria were recovered from the tubes of the conventional handpiece.

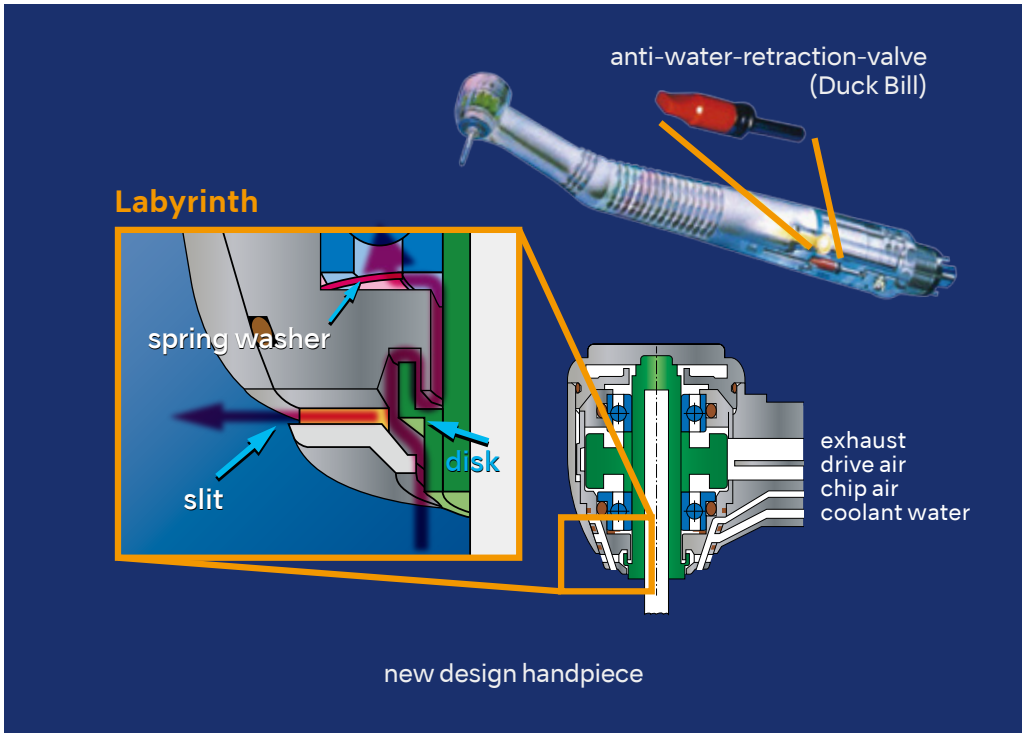
Conclusion

The data on the conventional handpiece clearly indicates that contamination does, in fact, reach the tubing. On the other hand, the new design can prevent contamination of the tubing ,by virtue of its dual barriers. When the new handpiece is operated without Duckbill, the water line becomes highly contaminated, as the conventional handpiece. With our design, however, the rotor and the exhaust duct are protected by the Labyrinth.
Since the Labyrinth and the Duckbill in the new handpiece are autoclavable, and since bacteria confined to the handpiece are killed by autoclave sterilization, the use of the design described here, in combination with proper sterilization should suffice in daily practice.
Needless to say, dental practitioners must always be aware of the importance of disinfecting dental units and not depend solely upon technology. The device described here, though novel, is but a partial solution to the problem of cross-infection.

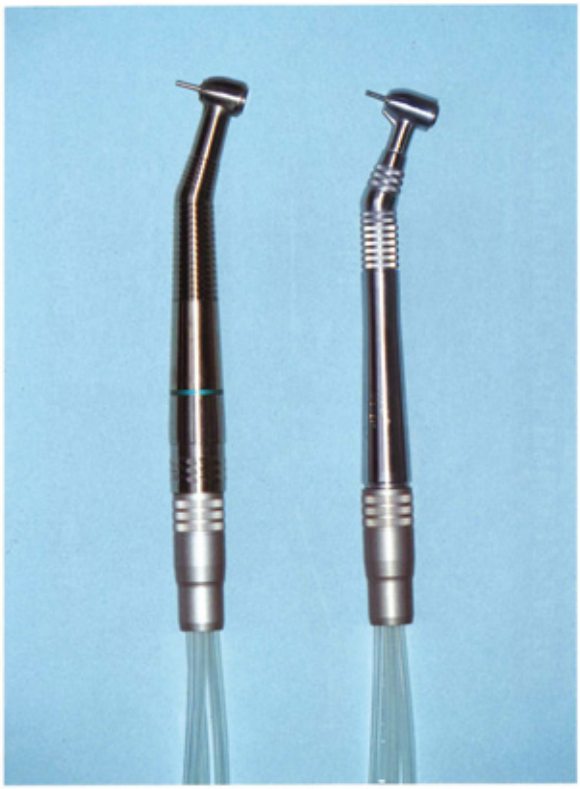
[Fig. 1] Two major pathways of internal contamination



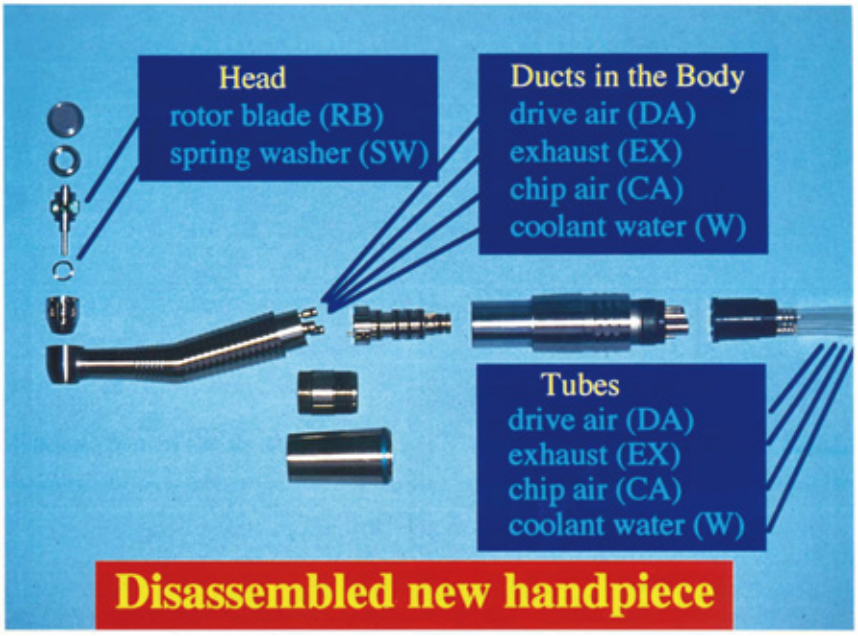
[Fig. 2] Anewly designed handpiece



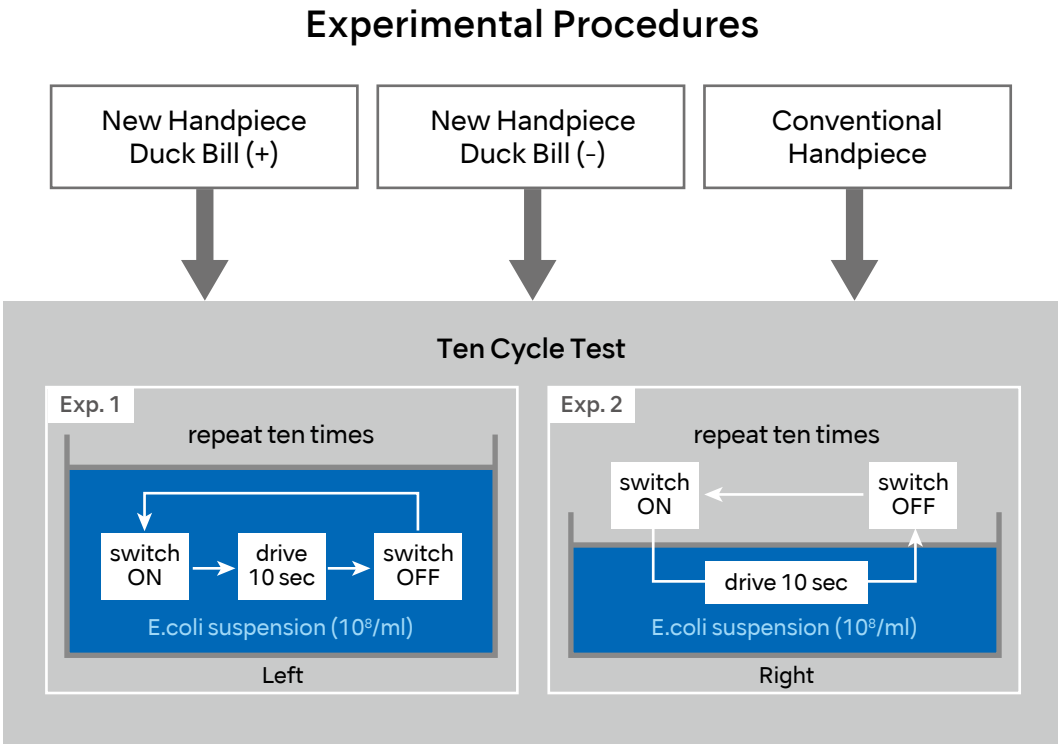
[Fig. 3] Handpieces tested left: new type handpiece with the Labyrinth right: conventional handpiece



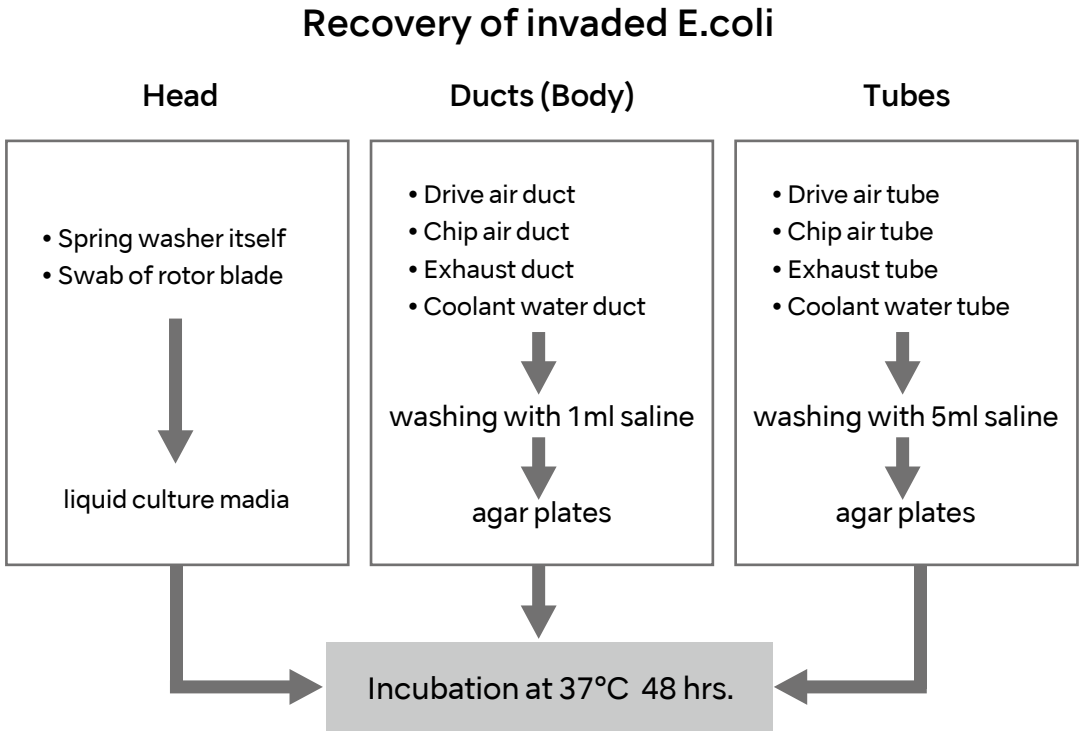
[Fig. 4] Disassembled new handpiece



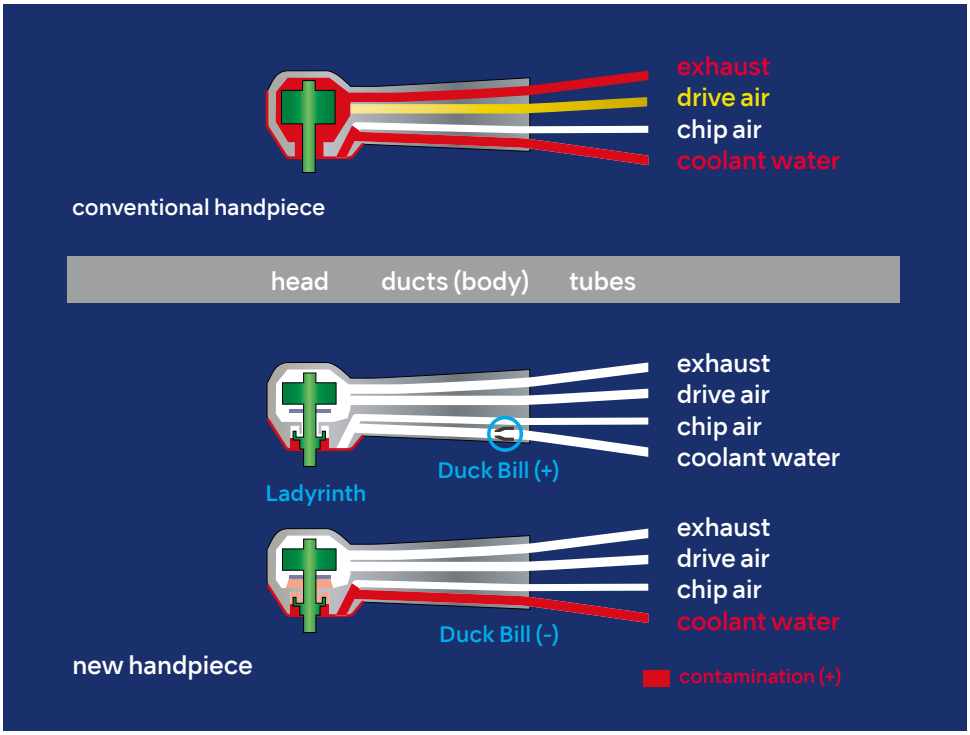
[Fig. 5] Experimental Procedures



[Fig. 6] Recovery of invaded E. coli



[Fig. 7] Comtamination of the handpiece



Contamination of the Handpiece

[Table 1] Recovered E. coli in the Exp. 1

		Head		Body (Duct)				Tube			
		SW	RB	DA	CA	EX	W	DA	CA	EX	W
New design Duck Bill (+)	1										
	2			5							
	3	+									
New design Duck Bill (-)	1	+				395	205				∞
	2	+					15				∞
	3	+					2235				∞
Conventional	1							∞		∞	∞
	2									∞	∞
	3							∞		∞	∞

Blank : no bacterial growth
\+ : bacterial growth + in liquid medium
∞ : uncountable colony formation

[Table 2] Recovered E. coli in the Exp. 2

		Head		Body (Duct)				Tube			
		SW	RB	DA	CA	EX	W	DA	CA	EX	W
New design Duck Bill (+)	1	+									
	2			25							
	3										
New design Duck Bill (-)	1	+									
	2	+									
	3	+									
Conventional	1										
	2										5
	3										

Blank : no bacterial growth
\+ : bacterial growth + in liquid medium
∞ : uncountable colony formation

Evaluation of Bacterial Suckback in Three Dental Hanpieces

University of Washington, U.S.A, 1999

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A report submitted to the Nakanishi Inc. (NSK), 1999

Introduction:

The specific objective of this study was to determine bacterial contamination of three dental handpieces when these handpieces were run in a bacterial solution, simulating conditions found in the mouth.

Methods and Materials for Bacterial Contamination:

The steps used in establishing the presence or absence of bacteria at the internal walls of the head were as follows:

(1) Sterilize all handpieces to be tested just prior to running the test procedures. The turbine was kept in the handpiece during this procedure.

(2) Sterilize all instruments to be used when removing the turbines.

(3) Apply the drive air to the handpiece until the turbine has turned to maximum revolutions. The time set for this was 20 seconds following application of drive air. Next, the turbine head was completely immersed in a bacterial solution containing oral streptococcal species. The drive air was removed, and the turbine allowed to come to a complete halt before removal from the bacterial solution.

(4) Remove the handpiece from the bacterial solution.

(5) A pre-sterilized 3mm twist drill 50 mm long was placed in the handpiece chucking mechanism. This allowed turbine removal without contamination of the turbine, or internal walls of the head.

(6) Using a sterilized turbine wrench, the head cap was removed. Special care was required to avoid contaminating the top of the turbine.

(7) The turbine was removed by holding the twist drill only. At no time during turbine removal, did the turbine or internal walls of the head come in contact with any non-sterilized object or surface.

(8) With the turbine removed, bacterial culturing could be accomplished by running a saline solution through the turbine, and collecting this in a presterilized glass container.

(9) The contents of the glass container were cultured for 48 hours on blood agar plates, then inspected for bacterial growth.

Note: Air pressure to all handpieces was 34 psi

Control Experiments:

Several control studies were needed to verify the final results.

(1) Verification of a Non-contaminated Air Supply:
Following sterilization, three NSK handpieces were run in air, then the turbines removed. The saline wash was applied, and cultured. This control was run once only for the three handpieces.

Results: No bacterial contamination from the air supply

(2) Verification that Bacteria Remain in the Turbine head
Following sterilization, the turbine was removed, and a measured amount of bacterial solution placed directly on the turbine blades. Each handpiece was run to full speed three times. The turbine was then removed, the saline wash applied, and cultured.

Results: Bacteria remained on the turbine blades.

(3) Verification that Bacteria remain on the Walls of the Turbine Enclosure for the NSK:
Same as for #2, except bacteria removal was done from the inner walls of the head- outside the actual turbine housing. One handpiece was tested three times.

Results: Bacteria remained on the turbine walls of the turbine enclosure for the NSK

(4) Verification of Bacteria outside the turbine for the Kavo:
Same as #3, except the Kavo Handpiece was used here, with bacterial collection from the walls of the turbine enclosure. One hand piece, three times.

Results: Bacteria remained on the turbine walls of the Kava hand piece.

(5) Verification that no Vital Bacteria remain Following Sterilization:
This was needed to verify that a complete bacterial kill was established during handpiece sterilization. One handpiece, three times.

Results: No vital bacteria remained following sterilization.

These control studies verified the following:

(a) No vital bacteria remained following sterilization. Thus additional tests on the same handpiece were not confounded by previous tests.

(b) No bacteria were in the air supply. Thus no artifact values were obtained from this source.

(c) If bacteria were sucked into the turbine space, some would remain. Thus bacteria would not simply be sucked in, then blown out the exhaust port leaving no trace in the turbine head.

(d) The speed of the turbine blades was not sufficient to eliminate bacteria from the blade surface due to centrifugal force.

(e) The speed of the turbine, and the accompanying whirling action of the air inside the turbine head, was not sufficient to eliminate bacteria from the inner walls of the turbine housing, due to air velocity and accompanying suction.

Experimental Tests:

In all, 3 separate tests were run on the model MACH std NSK handpieces. These included

(I) New handpiece	- new turbine	- 3 handpieces	- 3 trials each
(II) Old handpiece*	- old turbine	- 3 handpieces	- 3 trials each
(III) Old handpiece*	- new turbine	- 3 handpieces	- 3 trials each

* The old handpieces had been in operation in dental offices for at least two years, and the original turbines were left in these instruments for testing purposes. The new handpieces were taken directly from stock.

The additional handpieces tested were

Kavo 647B
Adec(W&H) TC-95

(a) New Kavo handpiece	- new turbine	- 3 handpieces	- 3 trials each
(b) New Adec handpiece	- new turbine	- 3 handpieces	- 3 trials each

Experimental Results:

The four categories for this, along with the results are given in the tables below.

(a) NSK handpieces

Test#	Handpiece	Turbine	Bacteria Present
1	New	New	No*
2	Old	Old	No*
3	Old	New	No*

* Results were consistent for all trials

(b) Other handpieces

Test#	Handpiece	Turbine	Bacteria Present
4	Kavo	New	No*
5	Adec	New	Yes*

* Results were consistent for all trials

Conclusions for First Series:

(1) The new NSK handpieces show no bacterial contamination in the turbine space when run up to full speed, immersed in a bacterial solution, then allowed to coast to rest while still immersed.

(2) The old NSK handpieces (2 years in dental offices) also showed no bacterial contamination in the turbine space with the original turbines still in the handpieces when subjected to the same conditions as in (1).

(3) With new replacement turbines, in the old NSK handpieces (2 years in dental offices) no bacterial contamination was found for the test conditions used.

(4) The new Kavo handpieces with new turbines, showed no bacterial contamination inside the head when subjected to these test conditions.

(5) The new Adec handpieces with new turbines, showed considerable bacterial contamination when subjected to these test conditions.

Addendum - Second Series tests:

At your request, additional tests were run. These test evaluated the presence (or absence) of bacteria at the distal end of the handpiece. The concern here was that bacteria could be sucked into the turbine space, but due to the high speed of the turbine, these bacteria would not be able to attach to the turbine blades or turbine head walls.

This test sequence required the following steps:

(1) Sterilize all hand pieces to be tested just prior to running the test procedures. The turbine was kept in the handpiece during this procedure.

(2) Sterilize all instruments to be used when removing the turbines.

(3) Apply the drive air to the handpiece until the turbine has turned to maximum revolutions. The time set for this was 20 seconds following application of drive air. During this step, the turbine head was completely immersed in a bacterial solution containing oral streptococcal species. The turbine was allowed to come to a complete halt before removal from the bacterial solution. This procedure was repeated three times for each handpiece.

(4) Remove the handpiece from the bacterial solution

(5) Using sterile rubber gloves, unscrew the sleeve covering the distal end of the handpiece.

(6) With the sleeve removed, bacterial culturing could be accomplished by running a saline solution over the uncovered section of the handpiece, and collecting this directly in a blood agar plate.

(7) The contents of the blood agar plate were cultured for 48 hours, then inspected for bacterial growth.

The handpieces tested here were the NSK and the Kavo, since both showed no bacterial contamination in the turbine area in the First Series tests.

Experimental Tests:

The following tests were run in this sequence

(a) NSK	new handpiece	- new turbine	- 3 handpieces	- 1 trial each
(b) Kavo	new handpiece	- new turbine	- 3 handpieces	- 1 trial each

Experimental Results:

Test#	Handpiece	Turbine	Bacteria Present
6	NSK-New	New	No*
7	Kavo-New	New	Yes*

* Results were consistent for all 3 trials run on each handpiece brand.

Conclusions for Second Series:

(1) The NSK handpieces were found to have zero bacterial contamination in the distal end of the handpiece.

(2) The Kavo handpieces were found to have considerable bacterial contamination in the distal end.

(3) For the Kavo handpieces, with no bacterial contamination in the turbine head(Test #4), but contamination in the distal end, one can only assume that the bacteria are moving so fast in the turbine head, that they cannot attach to the turbine walls. However, when these bacteria reach the distal end of the handpiece, the air stream slows, allowing bacterial attachment.

UW
UNIVERSITY OF WASHINGTON
Department of Restorative Dentistry
Division of Fixed Prosthodontics | Division of Operative Dentistry | Division of Biomaterials and Research | Division of Hospital Dentistry and General Pr

12th July, 1999.

Hiroji Sekiguchi
Marketing Manager, North America
Nakanishi Inc.
340 Kamihinata
Kanuma-Shi, Tochigi-Ken
Japan

Dear Hiroji

Both parts of the handpiece testing have now been completed, and the report appended to this letter provides the final results.

Based on our final testing, wherein bacterial contamination was investigated at the distal end of the handpiece, it appears that bacteria are sucked into the Kavo unit, but, since the turbine is moving extremely fast, no bacteria actually attaches to the turbine blades, or internal walls of the head. Obviously then, this suckback occurs when the turbine is spinning fast, and not when it is close to stopping. However, when the air flow slows down, as is the case when this air reaches the distal end of the handpiece, the slower air flow allows bacterial attachment, with recognizable contamination.

Our findings, show there was no bacterial suckback into your NSK handpieces, whether new, or in service for at least two years.

Should you need further information on this study, please contact me.

Sincerely

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Evaluation of the effectiveness of a "clean-head" design high speed dental handpiece

National University of Singapore, Singapore, 1999

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A report submitted to Nakanishi Inc. (NSK), 1999

AIM

To evaluate the effectiveness of a "clean-head" design high speed handpiece, in vitro

INTRODUCTION

One of the major problems in implementing effective infection control in dentistry is the potential for cross-infection via the dental handpiece. Many studies have shown that the possibility of contaminants being sucked back through the dental handpiece and into the unit water system is real (Scheid et al 1982, Lewis and Boe 1992, Lewis et al 1992, Mills et al 1993). As such, non-retractory valves are recommended to be incorporated into high speed handpiece systems to decrease or eliminate this risk (Crawford 1978, Bagga et al 1984). The non-retraction valve is usually sited in the coupling to the handpiece. This still allows the potential for blood and debris to enter the intricate mechanism of the high speed handpiece, which if not properly cleaned, could reduce the effectiveness of sterilization and even reduce the life-span of the handpiece. A novel approach is to use a "clean-head" design to prevent blood and debris from entering the handpiece's intricate mechanism to complement the benefits of a non-retraction valve.
This microbiological study was carried out to evaluate the effectiveness of a "clean-head" design high-speed handpiece.

MATERIALS AND METHODS

Two designs of high-speed handpieces were used in this in vitro evaluation. A conventional head design (KaVo, 630B) and another, with a "clean-head" design (NSK, MACH-QD). Both handpieces were used together with their respective couplings which house non-retraction valves.
The dental unit was specially fitted with a reservoir for sterile water to run through the dental unit instead of main water supply. Before each experimental run, the reservoir was filled with 70% alcohol and the waterlines sterilized by running the alcohol through the dental unit. Then, the reservoir was washed and filled with sterile water and the water lines flushed. Sterile water was used throughout the session. Four pieces of each type of handpiece were used. They want S/No of handpieces & couplings used. Both types handpieces were autoclaved for 15 minutes at 121 °C and subjected to the following protocol. Each handpiece was fitted with an autoclaved turbine bur. The handpiece was activated and 5 ml of effluent was collected as a negative control. Then, each handpiece was run for 3,

10-second bursts at full speed with the bur dipped into a brain heart infusion (BHI) broth culture of Streptococcus sanguis containing 10^8 colony forming units (CFU)/ml. Immediately after the bur was removed, 5 mls of effluent was collected. The handpiece and the non-retraction valve were then detached and both the air and water outlets were syringed with 5 mls of sterile saline and the effluents collected again. A total of 12 sets of readings were collected for each of the handpiece systems.
All effluents collected were subjected to the "pour plate technique" for enumeration of CFUs. The media used was a BHI agar. Each specimen collected was serially diluted to 10^{-5}, then dispensed onto empty petri dishes, followed by pouring of the cooled (48°C) BHI agar. The plates were incubated at 37°C for 48 hours, after which enumeration for CFUs was carried out.

Footnote

(a) Serial numbers of NSK handpieces : 42032, 30 047, 4 20 355, 4 2 2032
(b) Serial numbers of NSK couplings : QD-J M4 406

RESULTS

Tables 1 and 2 show the 12 sets of results of the clean-head and conventional handpiece respectively. Comparing the results of the 2 handpiece systems (Table 3), all components of the "clean head" handpiece system showed a marked reduction of CFU. There is a five-fold decrease of CFUs from the handpiece run with the "clean-head" system, whilst with the conventional handpiece run there was a two-fold decrease. The "clean-head" system coupling which houses the non-retraction valve and waterline showed no bacterial contamination(0 CFU/ml), whilst this was not so with the conventional handpiece system.

DISCUSSION

The results of this in vitro study demonstrated that the "clean-head" handpiece system used in conjunction with their non-retraction valve effectively decreased bacterial contamination. It consistently prevented bacterial "suck-back" into the unit water system.
The conventional system also prevented "suck-back" contamination of the unit water system, however, this was not consistent (4 of the 10 test runs). The contamination that did occur, was generally very low. A possible explanation for the bacterial contamination of the waterline in the conventional system could be that bacteria sucked back resulted in bacteria being lodged in the coupling. This could be because the internal design of the coupling provided pockets of area for bacterial retention or the water flow is not totally laminar allowing areas for bacteria to marginate and stagnate. Depending on the concentration or location of the contamination, a little could get through the non-retraction valve as it was closing. Lastly, could the alcohol used to disinfect the .waterline affect the material used in the conventional valve.
The new 'clean head' designed handpiece system used in combination with its non-retraction valve was very effective in preventing bacterial "suck-back" to the coupling housing the non-retraction value. The test bacteria recovered from the "clean head" handpieces were consistently lower by a factor of 10^2 compared to a conventional head design handpiece. This was confined to the handpiece and the coupling and unit water lines was consistently free of the test bacteria.
The clinical implication findings of this study are that using conventionally designed high speed handpieces, some bacterial contamination can be expected. Between patients, flushing of the water lines will therefore have to be performed. With the "clean head" system, this step could possibly be omitted. These will have to be confirmed in a clinical study which will be reported later.

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[Table 1.] Total colony forming units (CFU/ml) found in the various components of the "clean-head" handpiece system

	1	2	3	4	5	6
Strept. sanguis broth	1.33×10^8	9.50×10^7	2.20×10^8	3.44×10^7	7.00×10^7	3.80×10^7
Handpiece Run	430	214	1.38×10^4	545	3	2.15×10^3
Handpiece Water Inlet	0	160	4.25×10^3	4.30×10^2	0	215
Handpiece Air Outlet	0	0	0	0	0	0
Valve Air Outlet	0	0	0	0	0	0
Valve Water Inlet	0	0	0	0	0	0
Waterline	0	0	0	0	0	0

	7	8	9	10	11	12
Strept. sanguis broth	9.50×10^8	3.50×10^7	3.50×10^7	1.83×10^8	1.73×10^8	2.96×10^8
Handpiece Run	0	1.24×10^4	1.24×10^4	270	2.10×10^3	1.66×10^4
Handpiece Water Inlet	320	1.60×10^4	1.60×10^4	5	2	3.90×10^3
Handpiece Air Outlet	0	5.20×10^3	5.20×10^3	0	0	0
Valve Air Outlet	0	0	0	0	0	0
Valve Water Inlet	0	0	0	1	0	0
Waterline	0	0	0	0	0	0

[Table 2.] Total colony formning units (CFU/ml) found in the various components of the conventional handpiece system

	1	2	3	4	5	6
Strept. sanguis broth	2.40×10^7	8.60×10^6	1.29×10^8	2.40×10^7	2.60×10^7	2.40×10^7
Handpiece Run	9.40×10^3	$> 10^8$	7.88×10^6	6.40×10^4	1.06×10^6	6.00×10^5
Handpiece Water Inlet	5.90×10^3	1.60×10^4	$> 10^8$	1.05×10^3	1.35×10^3	4.20×10^3
Handpiece Air Outlet	5.90×10^5	$> 10^8$	2.52×10^6	4.30×10^4	2.50×10^4	2.07×0^3
Valve Air Outlet	9.00×10^3	$> 10^8$	7.10×10^2	22	96	23^3
Valve Water Inlet	2.90×10^2	6.12×10^3	7.20×10^3	50	2	2
Waterline	0	1.04×10^2	0	7	12	1

	7	8	9	10	11	12
Strept. sanguis broth	1.80×10^7	1.80×10^7	1.27×10^8	1.27×10^8	8.20×10^7	2.40×10^7
Handpiece Run	2.16×10^6	4.00×10^5	6.10×10^5	4.00×10^5	6.10×10^5	8.40×10^4
Handpiece Water Inlet	3.90×10^4	1.52×10^5	4.00×10^3	1.06×10^5	5.60×10^4	1.15×10^4
Handpiece Air Outlet	7.48×10^6	4.18×10^6	1.26×10^5	1.57×10^7	4.40×10^6	6.50×10^5
Valve Air Outlet	$> 10^8$	$2.24x\ 10^2$	0	2.60×10^4	1.14×10^3	1.04×10^4
Valve Water Inlet	5.40×10^2	2.90×10^2	0	1.26×10^2	$1.48x\ 10^3$	8.50×10^2
Waterline	8.00×10^2	0	0	40	1	47

[Table 3.] Comparison of total colony forming units (CFU/ml) from various parts of a "clean-head" and conventional handpiece systems.

	"Clean-head"		Conventional	
Source	Median	Range	Median	Range
Strept. sanguis broth	1.14×10^8	3.44×10^7 - 9.5×10^8	2.4×10^7	8.6×10^6 - 1.29×10^8
Handpiece Run	1.32×10^3	0 - 1.66×10^4	5.05×10^5	1.0 - 1.0×10^7
Handpiece Water Inlet	2.67	0 - 4.2×10^3	1.37×10^4	1.05×10^3 - 1.0×10^6
Handpiece Air Outlet	0	0 - 5.2×10^3	1.58×10^6	2.5×10^4 - 1.57×10^7
Valve Water Inlet	0	0	290	0 - 7.2×10^3
Valve Air Outlet	0	0	1.6×10^3	0 - 1.0×10^6
Waterline	0	0	4.5	0 - 800

Risk of Hepatitis B Virus Transmission via Dental Handpiece and Evaluation of an Antisuction Device for Prevention of Transmission

Sichuan University, China, 2007

CONCISE COMMUNICATION

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INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY
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We evaluated the risk of hepatitis B virus (HBV) transmission via dental handpieces and the effects of an antisuction device in preventing HBV contamination. The results of our study show that under certain conditions, HBV transmission can occur when an antisuction device is used during dental procedures. We conclude that such devices may decrease contamination, but do not eliminate it. Infect Control Hosp Epidemiol 2007; 28:80-82

In dentistry, bloodborne pathogens are likely to be transmitted via many types of equipment; air-driven handpieces with high-speed drills have been suggested as potential sources of such transmission.[1,2] When the high-speed drill stops rotating, contaminated fluid from the external environment is retracted into various compartments of the handpiece and settles in the dental unit. The contaminated fluid is then expelled during the next procedure.[3,4]
A special antisuction device inside the handpiece has been designed to prevent cross-infection between patients and dental personnel and among patients. However, previous cross-contamination studies are limited.[5-7] Moreover, few studies have indicated whether the handpiece can become internally contaminated with patient material during routine clinical practice.[8]
We investigated the rate of transmission of hepatitis B virus (HBV) in an artificial viral environment and among patients with hepatitis. We sought to determine whether an antisuction device could reduce contamination in the air chamber of a high-speed handpiece.

METHODS

Dental units. Two types of dental handpieces (Nakanishi [NSK]) were used in this study. One was equipped with anantisuction device; the other was structurally similar, but lacked the antisuction device. Both dental handpieces were connected to dental units (Nakanishi [NSK]). Identical cylindrical burs without cutting edges were inserted into each handpiece. All the handpieces and the attached equipment were sterilized at 135°C and 1.5 kg of pressure before being used.

Artificial model and clinical situations. HBV recombinant plasmid solutions (with concentrations of 10^{-6} μg/μL and 10^{-9} μg/μL; prepared at our institution [Huaxi Hospital]) were placed in separate containers, and a turbine head was

immersed in each solution. While immersed in the liquid, the handpiece was run for 10 seconds and then stopped for 10 seconds. This procedure was repeated either 5 or 10 times. The rotating speeds of the turbines were adjusted to almost identical rates of 400,000 rpm.
In the clinic, 40 HBV DNA-positive patients were selected for inclusion in the study. The purpose of the study was explained to them, and all agreed to participate. The blood concentrations of HBV DNA in these patients ranged from 10^7 to 10^9 copies/mL . The patients were divided into 2 groups according to the HBV DNA concentrations in their saliva and their clinical periodontal status. The fluorescent quantitative polymerase chain reaction technique was used to test for HBV DNA concentrations in saliva. The patients in group 1 had no bleeding in the gingiva, mucosa, or other soft tissues in the mouth, and their viral DNA concentrations were comparatively low (mean ± SD, $10.67 \times 10^5 \pm 20.16 \times 10^5$ copies/mL), whereas patients in group 2 had serious gingivitis and higher concentrations of viral DNA (mean ± SD, $16.08 \times 10^5 \pm 20.22 \times 10^5$ copies/mL). A significant difference ($P < .05$) was found between concentrations of viral DNA in the 2 groups of patients. Dental prophylaxis was performed, and salivary samples were taken from both groups according to the same procedures and technique standard (the handpiece was run across the saliva or blood on the surface of the mandibular teeth). Both types of handpieces were operated in the same position to perform the same procedure on both sides of each patient's mouth. The tripleblind method and randomization principle were used in the study.

Evaluation of viral retraction. Handpieces equipped with an antisuction device were compared with devices without this feature. At the end of the procedure, the equipment was scrubbed externally with disinfectant detergent (iodophore) 3 times and wiped with bibulous paper. Internal contamination samples were taken from several locations in the handpiece (ports for the air and water lines that serve the patient [chip air port, chip water port], driving air port, and exhaust port, as well as from the water tank in the dental unit) using identical paper points, which were transferred to fresh tubes containing 500 µL phosphate-buffered saline at a concentration of 0.01-mol/L (pH 7.2). Samples were tested for the presence of HBV DNA with polymerase chain reaction analysis, and polymerase chain reaction markers were used to define a positive finding of HBV contamination.

RESULTS

Viral retraction in handpieces and water tanks. Table 1 gives the rates of contamination with HBV plasmids due to retraction for different handpieces and different sites. Each value represents the ratio of positive samples to the total of 10 samples tested for each site. In both the chip water and chip air ports ($P < .05$), the rates of contamination were determined to be significantly greater (on the basis of x^2 test) with a conventional handpiece than with the antisuction designs. However, no significant differences in the rates of contamination were found between the 2 types of handpieces in the driving air port or exhaust port or the water tank in the dental units ($P >. 05$). The number of stops during the tests (either 5 or 10) had no effect on contamination ($P > .05$). Therefore, chip water and chip air ports were tested in subsequent studies.

Viral retraction with different HBV plasmid solutions. When the turbines were stopped in HBV plasmid solutions with a concentration of 10^{-6} µg/µL, contamination was significantly lower in the chip water port of the handpieces equipped with antisuction devices (3 [15%] of these samples were contaminated) compared with conventional handpieces (14 [70%] of these samples were contaminated) ($P < .05$). However, no significant difference was observed between the 2 types of handpieces when the turbines were stopped in HBV plasmid solution with a concentration of 10^{-9} µg/µL of (3 [15%] of the samples from handpieces with anitsuction devices were contaminated, whereas 5 [25%] of sampled from conventional handpieces were contaminated; $P > .05$).

Viral retraction in the clinical situation. A comparison between the 2 handpieces' rates of contamination after retraction is presented in Table 2. For patients in group 1, rates were low, and no significant difference was found between the 2 types of handpiece ($P > .05$). However, for patients in group 2, rates of contamination of the chip air and chip water ports of the handpiece with the antisuction device were much lower than for the handpiece without the device ($P < .05$) (Table 2).

[TABLE 1.] Rate of Contamination With Hepatitis B Virus Plasmids in Different Handpiece Sites.

Handpiece site	No. (%) of samples contaminated, by test protocol and type of handpiece			
	5 stops		10 stops	
	Handpiece with antisuction device	Handpiece without antisuction device	Handpiece with antisuction device	Handpiece without antisuction device
Driving air port	7 (70)	6 (60)	4 (40)	5 (50)
Chip water port	1 (10)	7 (70)	2 (20)	7 (70)
Chip air port	2 (20)	7 (70)	3 (30)	8 (80)
Exhaust port	2 (20)	3 (30)	5 (50)	6 (60)
Water tank	3 (30)	6 (60)	2 (20)	5 (50)

NOTE. Ten samples were tested for each site. For definitions of "chip air" and "chip water," see "Evaluation of viral retraction," in Methods.

[TABLE 2.] Rate of Contamination With Hepatitis B Virus in the 2 Types of Handpieces for the 2 Patient Groups

Handpiece type	No. (%) of samples contaminated, by patient group			
	Group 1		Group 2	
	Chip water port	Chip air port	Chip water port	Chip air port
Handpiece with antisuction device	4 (20)	3 (15)	5 (25)	6 (30)
Handpiece without antisuction device	5 (25)	5 (25)	12 (60)	14 (70)

NOTE. Twenty samples were tested for each site, for both group 1 and group 2. For definitions of patient groups, see "Artificial model and clinical situations," in Methods. For definitions of "chip air" and "chip water," see "Evaluation of viral retraction," in Methods.

DISCUSSION

It is well known that high-speed dental handpieces take up and expel patients' tissues and fluids and thus can potentially transfer infectious agents from one patient to another and to dental healthcare workers.[1,9,10] The contaminating material is present in internal areas of the equipment, so it is not readily accessible to chemical disinfectant. Contamination inside the internal lines can still be detected even after correct sterilization of the handpiece.[5] Pathogens in saliva and sputum may be transmitted by this route.

HBV is one of the most serious bloodborne pathogens potentially transmissible through dental procedures, especially in China. We used an artificial model to simulate oral conditions and a clinical model that reflects the intraoral situations most frequently encountered during clinical practice. We found that the higher the concentrations of HBV plasrmid or DNA, the higher the rate of contamination of the 2 handpieces after retraction. However, the handpiece with the antisuction device showed much lower contamination than the handpiece without the antisuction device. The dental unit was actively picking up viruses inside the handpiece and the attachment tank when the bur was in contact with the contaminant fluid, especially when salivary viral concentrations were high. Thus, the risk of virus transmission between procedures via the handpiece is obvious. Dental healthcare workers and patients should therefore be protected from being exposed to the risk of infection from bloodborne or salivaborne pathogens.

No significant difference was found between the contamination rates in the 2 patient groups after use of the handpiece with the antisuction device, whereas a significant increase was found when the handpiece without the antisuction device was used in patients with higher salivary HBV DNA concentrations. Thus, using handpieces with this antisuction device can reduce the problem of dental unit contamination in most intraoral clinical situations. However, it seems unlikely that this device can completely prevent suction when the turbine stops while the

handpiece is in contact with the oral fluid. The fact that the contamination rates were not zero indicates that there is risk of viral retraction during every dental operation. We conclude that such devices may decrease contamination but do not eliminate it. Therefore, antisuction devices cannot replace standard infection control measures, because viruses such as HBV can be retracted into various compartments of the handpiece and settle in dental units.

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